

**WAIMEA WASTEWATER TREATMENT PLANT
EFFLUENT REUSE/DISPOSAL ALTERNATIVE STUDY**

PREPARED FOR:

**COUNTY OF KAUAI
Department of Public Works**

PREPARED BY:

**Austin, Tsutsumi & Associates, Inc.
Civil Engineers • Surveyors
Honolulu • Wailuku • Hilo, Hawaii**

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March 7, 1994



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AUSTIN, TSUTSUMI & ASSOCIATES, INC.

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CONTINUING THE ENGINEERING PRACTICE FOUNDED BY H. A. R. AUSTIN IN 1934

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WAIMEA WASTEWATER TREATMENT PLANT

EFFLUENT REUSE/DISPOSAL ALTERNATIVE STUDY

I. EXECUTIVE SUMMARY

Alternatives for effluent reuse/disposal from the County of Kauai's (County) Waimea Wastewater Treatment Plant (WWTP) were evaluated. This report was prepared as a result of the pending expiration of the following two lease agreements:

- A lease agreement between Kikiaola and Kekaha Sugar Company (Kekaha) for cultivation of sugar cane by Kekaha on Kikiaola land. This lease expires on December 31, 1993.
- An agreement between Kikiaola and the County for discharge of effluent from the Waimea WWTP into Kikiaola's irrigation reservoir. This agreement expires on December 31, 1994.

Reuse alternatives that were evaluated include using effluent for irrigation of four different vegetation; (1) sugar cane, (2) seed corn, (3) pasture and (4) turf – either for a golf course or at Waimea Park. Disposal alternatives that were studied include effluent disposal via, (1) underground injection wells, or (2) an ocean outfall. Approximate construction costs were calculated for all the alternatives except for golf course irrigation, which would be a future solution. A summary of the alternatives evaluated is presented in Table 1.

Based on the cost and subjective factors in Table 1, it is recommended that injection wells, for disposal of effluent from the Waimea WWTP, be pursued by the County. The injection wells would be located on land owned by the County, at the site of the existing Wastewater Pump Station 'A'.

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Kikiaola, in the near future, is planning on developing the land on which their irrigation reservoir is located. Therefore, one injection well would be required when the reservoir becomes unavailable. The well would be the backup disposal system (instead of the reservoir) if effluent reuse is continued. This well should have a capacity of 1.2 mgd, which could handle the peak flow rate for the future WWTP capacity of 600,000 gpd. This peak flow rate is based on a documented peak to average flow factor of 2.0.

If effluent reuse is eliminated all together, then a second 1.2 mgd capacity well would be required to provide for a 100 percent backup system for the future WWTP capacity.

The County should file a UIC Application Permit with the State for construction of two injection wells, each with a capacity of 1.2 mgd, as soon as possible.

TABLE 1. SUMMARY OF EFFLUENT REUSE/DISPOSAL AL

ALTER NATIVE	DESCRIPTION		ESTIMATED CONSTRUCTION COST (\$1,000)		ADVANTAGES	
			MAJOR WORK	TOTAL		
"A"	Renegotiation of the Current Disposal Agreement		<ul style="list-style-type: none"> Modify existing lower effluent reservoir 	\$380	<ul style="list-style-type: none"> Least costly of all alternatives. Beneficial reuse of the effluent. 	• •
"B"	Golf Course Irrigation		N/A	N/A	<ul style="list-style-type: none"> Beneficial reuse of the effluent. May be a long-term solution in the future. 	• • • •
"C"	Ocean Outfall		<ul style="list-style-type: none"> Construct ocean outfall. 	\$10,000	<ul style="list-style-type: none"> No agreements between the County and Kiklaola required (other than pipeline easement). Lowest O&M cost of all alternatives. 	• •
"D"	Subsurface Disposal Via Injection Wells (No Reclamation)		<ul style="list-style-type: none"> Construct two injection wells. Install effluent transmission line. 	\$760	<ul style="list-style-type: none"> No agreements between the County and Kiklaola required, since injection wells would be located on County property. Can be implemented quicker than reuse alternatives. Less expensive than all alternatives except "A". 	•
"E"	Effluent Reuse	With storage reservoir.	<ul style="list-style-type: none"> Modify lower reservoir. Install drip irrigation system. 	\$1,360*	<ul style="list-style-type: none"> Beneficial reuse of the effluent. Alternative "E" is least expensive reuse alternative 	• • • •
"F"	<ul style="list-style-type: none"> Sugar cane mauka of the highway, pasture makai of the highway Scenario 1	With injection well.	<ul style="list-style-type: none"> Construct one injection well. Install drip irrigation system. 	\$1,39		

EFFLUENT REUSE/DISPOSAL ALTERNATIVES

ADVANTAGES	DISADVANTAGES
Best of all alternatives. Lowest cost of the effluent.	<ul style="list-style-type: none"> • Not likely to be long-term solution. • Requires modification of existing reservoir at present time.
Lowest cost of the effluent. Long-term solution in the future.	<ul style="list-style-type: none"> • Requires implementation of Kiklaola's Master Plan. • Requires supplemental study on further expansion of the WWTP and the effluent/disposal system. • Requires new agreement between the County and Kiklaola. • Kiklaola would require R-1 quality water.
Lowest cost between the County and Kiklaola. Lowest cost of all alternatives.	<ul style="list-style-type: none"> • Very expensive. • Not a beneficial reuse of the effluent.
Lowest cost between the County and Kiklaola. Lowest cost, since injection wells located on County property. Implemented quicker than reuse of the effluent. Lowest cost than all alternatives except reuse of the effluent.	<ul style="list-style-type: none"> • Not a beneficial reuse of the effluent.
Lowest cost of the effluent. "E" is least expensive reuse of the effluent.	<ul style="list-style-type: none"> • Not likely to be long-term solution. • Kiklaola will probably not renew lease with Kekaha, so sugar cane may not be cultivated. • Requires renegotiation of existing, or new, agreement with Kiklaola. • If lower reservoir is used for backup, then dependent upon design monthly percolation rate (DMPR) included in water balance calculations. Not enough storage available if DMPR is excluded. • County would be responsible for tubing within irrigated crop areas. • Kiklaola would require R-1 quality water.
Lowest cost of the effluent. Most likely lease their land to Kiklaola.	<ul style="list-style-type: none"> • Not likely to be long-term solution. • Requires renegotiation of existing, or new, agreement with Kiklaola. • If lower reservoir is used for backup, then dependent upon design monthly percolation rate (DMPR) included in water balance calculations. Not enough storage available if DMPR is excluded. • County would be responsible for tubing within irrigated crop areas. • Kiklaola would require R-1 quality water.
Lowest cost of the effluent. Has higher evapotranspiration than sugar cane and seed corn, and effluent can be used.	<ul style="list-style-type: none"> • Not likely to be long-term solution. • Requires renegotiation of existing, or new, agreement with Kiklaola. • More expensive than all other alternatives, except for "C". • County would be responsible for tubing within irrigated areas. • Kiklaola would require R-1 quality water.

II. INTRODUCTION

The purpose of this study is to determine the feasibility of the following alternatives, or combinations thereof, for reuse/disposal of effluent from the County of Kauai's (County's) Waimea Wastewater Treatment Plant (WWTP):

- Renegotiation of the current disposal agreement between the County and Kikiaola Land Company (Kikiaola).
- Subsurface disposal via injection wells.
- Irrigation reuse on crops, landscaping/turf or pastures.
- Irrigation reuse on a golf course proposed as part of Kikiaola's Master Plan for the area.

The terms "reclaimed water" and "effluent", and "reclamation" and "reuse", are used somewhat interchangeably throughout this study. The intended differentiation is that reclaimed water is effluent that is reused for some beneficial purpose -- in this study, for irrigation. Although physically the same, effluent, rather than reclaimed water, is treated wastewater that is discharged into injection wells.

The urgency of this study is predicated on the expiration of the following two agreements - both of which may possibly not be extended, due to Kikiaola's Master Plan for the study area:

- A lease agreement between Kikiaola and Kekaha Sugar Company (Kekaha) for cultivation of sugar cane by Kekaha on Kikiaola land. This lease expires on December 31, 1993.
- An agreement between Kikiaola and the County for discharge of effluent from the Waimea WWTP into Kikiaola's irrigation reservoir. This agreement expires on December 31, 1994.

The flow rates to be considered for this study are the current design capacity of the WWTP - 300,000 gallons per day (gpd) - and the "ultimate" expanded capacity of 600,000 gpd. As a matter of clarification, the future capacity of 600,000 gpd was



established in the early 1970's, and hence, does not consider flows expected to be generated from the recently prepared Kikiaola Master Plan. Therefore, a premise of this study is that implementation of the Kikiaola Master Plan will require a supplemental study on further expansion of not only the treatment capacity of the WWTP, but also of the effluent reuse/disposal system.

Related to this study is a separate Wastewater Facility Plan for the Waimea WWTP, which is currently being prepared. This Facility Plan will evaluate in detail the expansion of the WWTP from 300,000 to 600,000 gpd. Therefore, it is not in the scope of this reuse/disposal study to address the technical issues related to expansion of the WWTP or upgrading of treatment efficiency. However, a general discussion on required effluent quality for implementation of a successful reuse/disposal system is included in this study.

It is also not within the scope of this study to incorporate a Basis of Design Report, pursuant to the State Department of Health's (DOH's) guidelines for water reclamation. However, the primary issues of these guidelines are addressed to formulate a basis for potentially proceeding into this next step for implementation of a reuse plan.

The main text of this report includes - besides basic background information - an evaluation of the reuse alternatives. The alternative of disposal of effluent via injection wells is evaluated in Mink & Yuen, Inc.'s report, included as Appendix A. Conclusions and recommendations from Mink's report, however, have been extracted for inclusion into the final sections of the main text.

Also included for reference, as appendices to this report, are the following:

- Excerpts from the U.S. Soils Conservation Service's Soil Survey (Appendix B).
- The July 26, 1990 draft of Belt Collins & Associates' "Engineering Study for Kikiaola Master Plan" (Appendix C).
- A letter from the U.S. Environmental Protection Agency to DOH (Appendix D).
- A letter from Austin, Tsutsumi & Assoc. Inc. to DOH, and DOH's response letter (Appendix E).

III. BACKGROUND

A. Property Ownership and Land Ownership

The study area is located in the Waimea-Kekaha region on the southwestern portion of the island of Kauai. The study area is focused primarily on land which may be used for effluent reuse, namely, properties owned by Kikiaola and the County. (See Exhibits 1, 2 and 3.) The majority of the land area is owned by Kikiaola (Tax Map Keys: TMK: 1-2-06:3, 9, 41 and 42). Land owned by the County is limited to the sites for the Waimea Wastewater Treatment Plant (WWTP) (TMK: 1-2-06:36) and Wastewater Pumping Station (WWPS) 'A' (TMK: 1-2-06:37). Parcel 9, the 400 ± acre area mauka of Kaumualii Highway, is presently being leased to Kekaha by Kikiaola.

The portion of the study area mauka of Kaumualii Highway consists primarily of cultivated sugar cane fields and a small area of cultivated seed corn. The fields are divided by dirt cane haul roads and drainage ditches.

Parcel 42, the 42 acre area makai of the highway, is presently the site of a small resort development owned by Kikiaola called Plantation Cottages. Parcel 3 is presently being leased to Northrup King Co. for seed corn cultivation, and the remaining portion of the study area makai of the highway consists primarily of wasteland with grass and shrubs.

Land uses of property adjoining the study area include residential, government and agricultural activities. Kekaha is presently raising sugar cane on land leased from Augustus Knudsen along the western boundary of the area (Parcel 6). On the eastern boundary is Waimea Town, and State-owned land utilized for Waimea Elementary and Intermediate School (Parcel 33) and Waimea Park (Parcel 38). The Pacific Ocean constitutes the southern boundary of the project area, while to the north is the sloping lower mountains which extend northward to Kokee.

The State Land Use Commission and the County Planning Department have different land use classifications for the different parcels of the study area. (See



Table 2 for a brief summary.) The Conservation areas of Parcels 3 and 41 are along the shoreline.

TABLE 2. LAND USE CLASSIFICATIONS

PARCEL NUMBER	LAND USE CLASSIFICATION	
	State Land Use Commission	County of Kauai, Planning Department
3	Agricultural Conservation Urban	Project District
9	Agricultural	Project District
41	Agricultural Conservation	Project District; Open
42	Urban	Project District; Open

B. Climate

Temperatures in the Waimea-Kekaha region range from the mid 50's to the low 90's (degrees Fahrenheit), with an average temperature of 75°F. Average daily temperatures vary by about ten degrees between winter and summer and about 15 to 18 degrees between day and night.

Mean annual rainfall recorded at Station 944.00 from 1916 to 1983 amounted to 21.77 inches. (See Exhibit 2 for location of Station.) The distribution of rainfall from month to month varies from heavy rainfalls at times to very light at others. Winter months typically have the most rainfall.

The mean annual pan evaporation recorded at Station 944.00 from 1960 to 1983 amounted to 73.53 inches. Summer months typically have the highest evaporation rates.

Table 3 summarizes the mean monthly precipitation and pan evaporation for Station 944.00. It should be noted that even during the rainy winter months, the



evaporation rates exceed the precipitation rates. This climatological condition is ideal for an irrigation reuse program.

TABLE 3. MEAN MONTHLY PRECIPITATION AND
PAN EVAPORATION AT STATION 944.00

MONTH	PRECIPITATION ⁽¹⁾ (inches)	PAN EVAPORATION ⁽²⁾ (inches)
January	4.17	4.54
February	2.48	4.98
March	2.44	6.31
April	1.42	6.67
May	0.98	7.07
June	0.47	7.29
July	0.51	7.59
August	0.75	7.55
September	0.79	6.82
October	1.89	5.96
November	2.13	4.89
December	3.70	4.15
ANNUAL	21.77	73.53

(1) From "Rainfall Atlas of Hawaii", Report R76, State of Hawaii Department of Land and Natural Resources, June 1986. Years of data include: 1916 to 1983.

(2) From "Pan Evaporation: State of Hawaii, 1894-1983", Report R74, State of Hawaii, Department of Land and Natural Resources, August 1985. Years of data include: 1960 to 1983.

C. Topographic Features

The study area lies on part of the Mana Plain, which is characterized by generally flat slopes, with elevations ranging from sea level at the shoreline to about 30 feet mean sea level (msl) at the northern (mauka) boundary. The



elevation at the WWTP, approximately 1000 feet mauka of the highway, is about 6 feet msl.

The watershed area mauka of the study area rises abruptly around the 50-foot elevation with slopes of 5 to 35 percent, and up to 80 percent along the steep valley walls. Elevations vary from about 200 feet msl to 1300 feet msl at the upper boundary of the watershed.

D. Geology and Soils

The study area is comprised of a sequence of sedimentary strata (cap rock) resting on the basement rock of Napali basalt. The caprock varies in depth from 310 feet thick at the Waimea WWTP to 400 feet thick near the Kekaha Sugar Mill. The caprock sediments as a whole are poorly permeable and act as a confining layer on the Napali aquifer. (See Appendix A for additional information.)

General soil classifications were published by the U.S. Soils Conservation Service (SCS) for the Islands of Oahu, Kauai, Maui, Molokai, Lanai and Hawaii, in 1972. (See Exhibit 4.) Brief descriptions of the soils, as well as general physical properties, are provided in the SCS surveys. (See Appendix B.)

The portion of the study area which lies mauka of Kaumualii Highway consists mainly of Kekaha Series soils classified as clay, silty clay and stony silty clay loam. These series consist of well-drained soils with moderate permeability and zero to moderate erosion hazard. There are also areas of Nohili and Kaloko clay, which consist of poorly drained soils with moderately slow to slow permeability and zero to slight erosion hazard.

The area between the Underground Injection Control (UIC) Line and the highway is mostly filled land, which consists primarily of bagasse and slurry from sugar mills. This land type is not in a capability classification. Therefore, permeability and the amount of erosion are not provided by the SCS. However, information obtained from Kekaha indicates that the soil consists of a poorly drained, heavy clay, with a depth ranging from 3 to 6 feet.



Soils makai of the highway are mostly classified as Jaucaus loamy fine sand. These series consist of excessively drained, calcareous soils with rapid permeability and slight erosion hazard.

E. Floods and Tsunamis

The National Flood Insurance Program publishes Flood Insurance Rate Maps for the State of Hawaii which designate areas of flood hazard. (See Exhibit 5.) A large portion of the study area mauka of Kaumualii Highway (including the WWTP and WWPS 'A' sites), and a small area near the coast, are in a Special Flood Hazard Area inundated by 100-year floods with base flood elevations of eight and nine feet, respectively. Another portion of the study area makai of the highway is classified as Zone X, which is in an area of 500-year flood and/or an area of 100-year flood with average depths of less than one foot. The remaining portion of the study area mauka of the highway, and the area directly makai of the highway, are outside of the 500-year flood plain.

A small strip of land along the coastline is designated as Zone VE, which is a coastal flood area with velocity hazard (due to tsunami wave action) with base flood elevations of nine feet.

IV. DESCRIPTION OF EXISTING WASTEWATER SYSTEM

Before the existing Waimea wastewater system was installed, wastewater was disposed of by individual wastewater systems (i.e., cesspools and septic tanks). Due to the low ground elevation and high groundwater table of much of the urbanized area of Waimea, sewage routinely overflowed from these systems.

Cesspools were also located on the steeper slopes of Waimea Heights. Seepage water from these cesspools struck the impervious layer of old lava flows and the vertical seep was deflected laterally to such a degree that wastewater appeared on the ground surface adjacent to, as well as below the bottom of, the cesspool. This led to algae growths and foul odors.

Because of the problems of overflowing cesspools, future development was denied until wastewater treatment was provided.

In 1971, a report titled, "Preliminary Engineering Study of Sewerage and Sewage Disposal for the Waimea Town Area, Kauai, Hawaii", was prepared by Austin, Smith & Associates, Inc. (presently Austin, Tsutsumi & Associates, Inc.). This report addressed the need for a wastewater system for Waimea. The total area studied in the report was 400 acres and was bounded on the south by the Pacific Ocean, and on the east, by the Waimea River. To the north were the sloping lower mountains which extend northward to Kokee, and to the west were irrigated sugar cane lands. At the time of the report, 200 acres were urbanized or partially developed.

The following sections describe the wastewater system that was constructed for Waimea Town to eliminate the previously mentioned problems.

A. Wastewater Collection/Transmission

The wastewater collection and transmission system for Waimea is comprised of gravity lines, wastewater pump stations (WWPSs) and force mains. The existing wastewater collection system for Waimea was constructed in four phases. The first phase was constructed in 1972 and the second phase, which sewered the Central Waimea Area, immediately followed in 1973. The Waimea Heights Area was



sewered in 1980 and the Waimea Valley Area, shortly after in 1983. Exhibit 6 shows the existing Waimea wastewater system. A brief description of the four phases follows.

Phase I -- The wastewater collection system for Phase I consists of a gravity line, force mains and a pump station (WWPS 'A'). WWPS 'A' is an underground package station with a separate wet well. The pre-fabricated underground "tank" is covered on the exterior with fiberglass to resist corrosion from the brackish water.

WWPS 'A' is located on the mauka edge of Kaumualii Highway along the road to the WWTP. The station lifts all the wastewater from the sewer areas of Waimea to the WWTP and is designed for an average wastewater flow of 210 gallons per minute (gpm) and a peak flow of 850 gpm.

The Waimea WWTP and the 10-inch effluent force main to the effluent reservoirs were also constructed during this phase.

Phase II (Central Waimea Area) -- The wastewater collection system for Phase II sewer the Central Waimea Area and a portion of the land mauka of Kaumualii Highway. A second pump station (WWPS 'C'), similar to WWPS 'A', was also constructed.

WWPS 'C' conveys wastewater from approximately 30 acres makai of Kaumualii Highway, between the old pier and the west edge of town. The station is designed for an average wastewater flow of 50 gpm and peak flow of 275 gpm.

Phase III (Waimea Heights Area) -- The Heights Area of Waimea Town is at the southwest base of Kauai's two major mountains, Mt. Kawaikini and Mt. Waialeale. A steep cliff on the eastern edge separates the Heights and Waimea Valley Areas. The central area of Waimea Town lies immediately below the Heights and the western edge is bordered by cane fields.

The wastewater collection system for the Waimea Heights Area consists of approximately 6300 lineal feet of 8-inch gravity lines. The collection system for Waimea Heights connects to the system installed during Phase II at two locations near Huakāi Road.

Phase IV (Waimea Valley) -- The Waimea Valley Area is located off the northwest bank of Waimea River at an elevation ranging from 5 to 15 feet msl. The wastewater collection system is comprised of two pump stations (WWPS No. 1 and WWPS No. 2) and approximately 9500 lineal feet of 12-inch and 8-inch gravity lines. The pump stations are constructed of cast-in-place concrete wet wells with submersible pumps. The collection system connects to the sewer system from Phase II at two points, in Menehune Road and in Waimea Road.

B. Wastewater Treatment

In 1968, State and Federal laws required that tertiary treatment of wastewater or long ocean outfalls were required for discharge of effluent into the ocean. Meeting these requirements would have been very costly, so a more economical means of disposal was sought. The Waimea WWTP, constructed in 1972, was designed for secondary treatment utilizing extended aeration and chlorination of the effluent. The chlorinated effluent would combine with storm water and then be used for irrigation. Chlorination would kill the coliform bacteria and the nutrients remaining in the effluent would be used by sugar cane. Secondary treatment also provided for the stabilization of the raw sewage by removing the biochemical oxygen demand and suspended solids.

The Waimea WWTP, located on the eastern edge of the sugar cane lands of Kikiaola, was determined to be the best point to serve Waimea Town, as well as any future development by Kikiaola. Two existing large reservoirs, located above the cane fields, were used to hold the effluent, where it was combined with storm water, before being dispersed for irrigation.

The first phase of the treatment plant was designed for an average wastewater flow of 272,000 gallons per day (gpd). The WWTP included a standard two-tank system with a capacity of 300,000 gpd, which allowed for a 10% increase in wastewater flow. The two tanks allowed for partial treatment of the wastewater during emergencies when one tank might be taken off-line.

Treatment process of the wastewater includes comminuting and degritting, aeration, final settling and then chlorination. The chlorinated effluent is then pumped to the effluent reservoirs. The sludge is routed to the aerated sludge holding tank, for stabilization, and subsequently pumped to the sludge drying beds for dewatering. Exhibits 7 and 8 show the existing Waimea WWTP site plan, and the Waimea WWTP hydraulic profile, respectively. Design data for the existing WWTP are presented in Table 4.

The future wastewater flow from the Waimea area was estimated to be 422,000 gpd. Allowances were made for future expansion of the WWTP of up to 600,000 gpd to accept future flows from Waimea – as well as wastewater flows from Kekaha Town, which lies less than three miles from the Waimea WWTP. This could be accomplished by installing two more tanks at 150,000 gpd capacity, each. Theoretically, the Waimea WWTP could be expanded to 900,000 gpd by enriching the oxygen supply in the compressed air, should it ever become necessary. However, as of June 1993, the wastewater flow rate has not exceeded 300,000 gpd and, therefore, expansion of the existing Waimea WWTP has not been necessary.

The wastewater treatment plant was designed in accordance with the ASCE - WPF Manual 36 on "Sewage Treatment Plant Design" and the Ten States Standards. The plant was also designed to meet practical requirements of the State and Federal Water Quality Administration Standards.

TABLE 4. TREATMENT PLANT DESIGN DATA

DESIGN POPULATION	3,000
DAILY SEWAGE FLOW PER CAPITA	100 gpd
DESIGN DAILY FLOW	300,000 gpd
DESIGN AVERAGE FLOW RATE	208 gpm
DESIGN MAXIMUM FLOW RATE (PUMP CAPACITY)	1,050 gpm
DESIGN RAW SEWAGE BIOCHEMICAL OXYGEN DEMAND (B.O.D.)	250 mg/l 625 #/day
DESIGN RAW SEWAGE SUSPENDED SOLIDS (S.S.)	200 mg/l 510 #/day
AERATION TANKS:	
DETENTION TIME (TOTAL)	24 hours
VOLUME OF AIR	2,000 cf/#BOD 870 cfm
SETTLING TANKS:	
SURFACE SETTLING RATE	<600 gal/sf/day
WEIR OVERFLOW RATE	<7,000 gal/f/day
RECIRCULATION RATE	>1 to 1
FINAL CLARIFIER DETENTION	>4 hrs.
VOLUME OF AIR (SLUDGE HOLDING TANK)	90 cfm
VOLUME OF HOLDING TANK	3,000 cf
B.O.D. REMOVAL	90 %
B.O.D. IN CLARIFIER EFFLUENT	25 mg/l
AVERAGE CHLORINE DOSAGE	8 - 10 mg/l
CHLORINE USAGE	25 - 26#/day
CHLORINE CONTACT TIME	30 min. +
OVERALL EFFICIENCY	93 %

Current conditions, and performance, of the WWTP are summarized in Table 5. The average effluent flow rate ranged from a minimum of 209,000 gpd to a maximum of 274,000 gpd, with a median of 247,000 gpd, during the period of January 1992 through April 1993. The effluent is of high quality with both the Biochemical Oxygen Demand (BOD) and the Total Suspended Solids (TSS) well below 10 mg/l, and most of the time, below 5 mg/l.

According to County records, there are only 72 houselots in Waimea — of which 62 lots are still vacant — that have yet to hook up to the County system. Based on $400 \pm$ gpd per lot, the additional flow from these lots would be 29,000 gpd, which suggests a "build-out" median average flow (without the Kikiaola Master Plan) of 270,000 — 280,000 gpd.

C. Effluent Reuse/Disposal

The chlorinated effluent from the WWTP is pumped, via a 10-inch force main, to two large reservoirs located above the cane fields near the Waimea Heights Area. The effluent can be routed to either the "upper" or the "lower" reservoir by a manually operated valve. The volumes of the upper and lower reservoirs are approximately 10 million gallons (MG) and 8 MG, respectively.

Presently, a large portion of the storm water runoff, from the drainage basin mauka of the study area, is intercepted by a network of irrigation ditches and dispersed throughout the cane fields. Some of the storm water that enters Kekaha Ditch is routed to the upper reservoir, and then released into the lower reservoir via a slide gate. The lower reservoir can also be supplemented by a water well located approximately 2,300 feet makai of the lower reservoir. This well also pumps storm water runoff and excess irrigation water from the surrounding sugar cane fields.

The effluent is released from the lower reservoir into an irrigation ditch, and from there dispersed to the nearby sugar cane fields for irrigation.

The current practice is to pump the effluent primarily into the lower reservoir, and to isolate storm water from entering this reservoir from the upper reservoir, via closure of the slide gate. Presently, all the effluent is being used by Kekaha for irrigation of sugar cane, and by DeKalb Plant Genetics for irrigation of seed corn.



V. DESCRIPTION OF EXISTING IRRIGATION SYSTEMS

Currently, there are three different land uses in the vicinity of the Waimea WWTP which use various forms of irrigation. The three uses are for production of sugar cane, seed corn, and landscaping/turf. A brief description of the existing irrigation system for each of these land uses follows.

A. Sugar Cane

Kekaha is presently leasing from Kikiaola approximately 400 acres of land adjacent to the WWTP for cultivation of sugar cane. Approximately 250 acres of this land, lying above the UIC Line, is irrigated with mountain water from Kekaha Ditch via a drip irrigation system. The drip irrigation system is a low pressure system and, therefore, does not require pumping.

Approximately 160 acres of sugar cane land, which lies below the UIC Line, is irrigated with effluent from the reservoirs, via surface irrigation.

There are no sprinkler systems and the irrigation water is conveyed to the sugar cane fields primarily by irrigation ditches.

A typical sugar cane cultivation schedule is approximately 20 months. The sugar cane is fertilized for the first 12 months, with no fertilization during the last eight months. At the start of the crop cycle, the sugar cane is irrigated one day every 10 to 15 days at a rate of three-acre-inches. As the crop matures, irrigation is decreased to about every 20 days, at the same rate. The last two months of the crop cycle are fallow (i.e., no irrigation during this time).

The start of the sugar cane crop cycles are staggered, such that 60 to 70 percent of the crops are irrigated throughout the year. Consequently, the average sugar cane irrigation consumption is approximately 1.0 million gallons per day (mgd) per 100 acres. About half of the crops are harvested every year.



B. Seed Corn

DeKalb Plant Genetics leases approximately 23 acres of land from Kikiaola near the WWTP for cultivation of seed corn, of which approximately 15 acres are planted each season. The present irrigation system utilizes effluent/storm water from the lower reservoir with a sprinkler system at 50-60 pounds per square inch (psi) of head. Since the Waimea soils are fairly heavy (i.e., it holds water well), the current irrigation rate is once a week at 3/4-inch to 1-inch, which corresponds to approximately 0.70 mgd per 100 acres. The normal procedure is to soak the ground well in October and November and then taper off irrigation. Due to a corn virus which effects the west side of Kauai, a voluntary "corn-free" period is implemented, during which time the corn is not irrigated. This corn-free period takes place during August and September.

C. Landscaping/Turf

Kikiaola currently uses a dual system for potable and non-potable water at their Plantation Cottages. Potable water is obtained from the County system. Non-potable water is obtained from Waimea River, and used for irrigation of approximately 42 acres of landscaping and turf located makai of Kaumualii Highway and directly west of Waimea Town. The river water is conveyed from Waimea Ditch via an old 8-inch pipe, which is in poor condition, and will most likely have to be replaced in the near future. This 8-inch pipe runs down Waimea Canyon Road and crosses Kaumualii Highway. (This system used to be the main source of water for the mill.) The irrigation water is then dispersed throughout the 42 acres. Water for the irrigation system is also supplemented by water from a well, located on Kikiaola land, just makai of the highway and on the mauka edge of the property. (See Exhibit 2 for location of well.)

VI. DEPARTMENT OF HEALTH REQUIREMENTS

A. Underground Injection of Effluent

The Department of Health (DOH) has been regulating underground injection of effluent in accordance with Hawaii State Administrative Rules, Title 11, Chapter 23, "Underground Injection Control", and Chapter 62, "Wastewater Treatment and Disposal". The former is the more specifically applicable regulation for injection wells. The latter is more generally applicable, as it includes the requirements for the disposal component of a treatment system (e.g., standby capacity for injection wells).

An important aspect of Chapter 23 is the establishment of the Underground Injection Control (UIC) Line. This line delineates the limits mauka of which injection of effluent is not allowed to preserve potential groundwater aquifers. The Waimea WWTP borders this line, but on the mauka side. One of the criterion for establishment of the UIC Line by DOH was that the total dissolved solids (TDS) concentration of the receiving groundwater be at least 5,000 mg/l.

A recent occurrence has been the involvement by the U.S. Environmental Protection Agency (EPA) in issuing underground injection permits. In essence, EPA does not recognize the UIC Line as being the delineation for injection of effluent. Furthermore, EPA's criterion for potential potable groundwater development is that the TDS concentration of the receiving aquifer must be at least 10,000 mg/l.

Based on DOH's regulations and EPA's over-riding criterion, the injection well(s) must be both makai of the UIC Line, and the well must be deep enough to inject the effluent into an aquifer with a TDS concentration exceeding 10,000 mg/l.

Chapter 62 requires the following effluent quality for disposal via injection wells:

- Five-day biochemical oxygen demand (BOD) shall not exceed 30 mg/l (arithmetic average of composite samples);



- Total suspended solids (TSS) shall not exceed 30 mg/l (arithmetic average of composite samples); and
- Chlorine residual shall not be less than 0.1 mg/l (any grab sample).

Past experiences with injection wells, however, indicates that a "rule-of thumb" maximum BOD/TSS concentrations of 5 mg/l is desirable - i.e., a 30 mg/l effluent would probably result in frequent clogage of the well.

Another qualitative parameter - which is not included in Chapter 62, but expected to be considered in EPA-issued injection well permits - is nutrient concentration of the effluent (i.e., nitrogen and phosphorus). The reason for concern is that subsurface migration of nutrient-rich effluent into coastal waters could result in algal blooms. A study is presently being conducted for the Lahaina Wastewater Reclamation Facility on Maui in regards to this matter. The results of this study are not yet available.

EPA reviewed the June 25, 1993 draft of this report, and concluded that nutrient removal for the Waimea WWTP effluent would not be necessary if certain conditions are met. (See Appendix D for EPA's letter to DOH, Safe Drinking Water Branch.) Their comments are as follows:

- If injection is into an aquifer that has greater than 10,000 mg/l total dissolved solids, then injection is not into an underground source of drinking water (USDW) and drinking water standards do not apply.
- If injection is into a USDW or the injectate migrates into a USDW, then EPA could require the injectate to meet maximum contaminant levels (MCLs).
- Should an injection well be approved and surface water quality problems develop, such as algal blooms, EPA may request studies to determine if effluent from the injection wells is reaching the ocean. If it is shown that effluent is entering the ocean, then the injectate would be subject to surface water standards.



Through discussions with DOH, it was verified that the Safe Drinking Water Branch concurs with EPA's findings. If underground injection wells are to be constructed, then permits would be issued by the State, not EPA.

Another regulatory issue is the capacity of the injection well(s), and the need for standby capacity. Chapter 62 requires that the primary injection well **and** a standby injection well **each** have the capacity to accommodate the peak flow from the WWTP. (The peak flow can be determined by using the Babbitt formula or, DOH may consider the historical flow records as a substitute, provided the records include extreme flow conditions. [See Appendix E.]) This is a definite requirement when the only method of disposal is injection wells. However, it becomes interpretive when the primary method for effluent discharge is reuse, with injection well(s) as a backup. The need for a standby injection well - or for that matter, any injection well at all - becomes even more questionable if the reuse system has an effluent storage component as a backup.

Based on correspondence with DOH's Wastewater Branch (Appendix E), which regulates Chapter 62, it was determined that the following DOH requirements would apply to an injection well(s) as a backup to a DOH-approved reuse system:

- No injection wells are required if the reuse system has a reclaimed water reservoir as a backup. The capacity of such a reservoir must conform to DOH's guidelines for reuse of reclaimed water.
- A single injection well - capable of accommodating the peak flow - is sufficient as a backup to the reuse system, in lieu of a backup reclaimed water reservoir.

B. Water Reclamation

DOH recently completed their "Guidelines for the Treatment and Use of Reclaimed Water", November 22, 1993. Although these guidelines are not expected to be adopted as Administrative Rules for at least a year-and-a-half, DOH



SUITABLE USES OF RECLAIMED WATER	R1	R2	R3
Parks, elementary schoolyards, athletic fields and landscapes around some residential property	A	U	N
Roadside and median landscapes	A	U/B	N
Non-edible vegetation in areas with limited public exposure	A	AB	U
Sod farms	A	AB	N
Ornamental plants for commercial use	A	AB	N
Food crops above ground & not contacted by irrigation	A	U	N
Pastures for milking and other animals	A	U	N
Fodder, fiber and seed crops not eaten by humans	A	AB	DU
Orchards and vineyards bearing food crops	A	DU	DU
Orchards and vineyards not bearing food crops during irrigation	A	AB	DU
Timber and trees not bearing for crops and timber	A	AB	DU
Food crops undergoing commercial pathogen destroying process before consumption	A	AB	DU
SUPPLY TO IMPOUNDMENTS: (A)llowed (N)ot allowed			
Restricted recreational impoundments	A	N	N
Basins at fish hatcheries	A	N	N
Landscape impoundments without decorative fountain	A	A	N
Landscape impoundments with decorative fountain	A	N	N
SUPPLY TO OTHER USES: (A)llowed (N)ot allowed			
Flushing toilets and urinals	A	N	N
Fire fighting	A	N	N
Commercial and public laundries	A	N	N
Cooling saws while cutting pavement	A	N	N
Decorative fountains	A	N	N
Washing yards, lots and sidewalks	A</		



SUITABLE USES OF RECLAIMED WATER	R1	R2	R3
Industrial Process with exposure of workers	A	N	N
Cooling or air conditioning system without tower, evaporative condenser, spraying, or other features that emit vapor droplets	A	A	N
Cooling or air conditioning system with tower, evaporative condenser, spraying, or other features that emit vapor or droplets	A	N	N
Industrial boiler feed	A	A	N
Water jetting for consolidation of backfill material around potable water piping during water shortages	A	N	N
Water jetting for consolidation of backfill material around piping for reclaimed water, sewage, storm drainage and gas; and electrical conduits	A	A	N
Washing aggregate and making concrete	A	A	N
Dampening roads and other surfaces for dust control	A	A	N
Dampening brushes and street surfaces in street sweeping	A	A	N

REFERENCE: Department of Health's "Guidelines for the Treatment and Use of Reclaimed Water", November 22, 1993.

The following precautions apply to R-2 Water:

- Signs shall be posted where reclaimed water is used.
- Adequate measures shall be taken to prevent ponding of reclaimed water.
- Reclaimed water shall always be managed to avoid conditions conducive to proliferation of mosquitoes and other disease vectors, and to avoid creation of a public nuisance or health hazard;
- No discharge, runoff, or overspray shall extend beyond the approved use area boundaries.
- Spray of reclaimed water shall not be allowed to contact an external drinking water fountain.



- R-2 water used in spray irrigation shall be performed during periods beginning when the area is closed to the public and the public is absent from the area, and end a least one hour before the area is open to the public. All subsurface irrigation may be performed any time.
- Spray irrigation of landscape or crops shall be limited so that the outer periphery of the irrigated area is not within 500 feet of:
 - a. A residence or property; or
 - b. A place where public exposure could be similar to that at a park, elementary school yard or athletic field.
- Whether the discharge is from a tank truck, sprinkler, or other device, or whether the discharge is runoff, the application of R-2 water shall be controlled by complying with the following:
 - a. Creation of visible mist is minimized;
 - b. Direct, overspray, or runoff, is confined to the approved use area;
 - c. Direct, overspray, or runoff does not contact or enter a dwelling, food handling facility, passing vehicle, or a place where the public may be present;
 - d. Direct, overspray, or runoff does not contact a drinking fountain, a table, a chair, bench, barbecue area, a yard at a residence, or an area with frequent human contact;
 - e. Direct, overspray, or runoff shall not be allowed to contact or enter a place where access and exposure to wetted surface, could be similar to that at a park, playground, or school yard.

- There shall be no irrigation within a minimum of 100 feet of any drinking water supply well.
- The outer edge of the impoundment shall be located at least 300 feet from any drinking water supply well.
- Drainage shall be controlled to prevent reclaimed water from coming within 100 feet of a drinking water supply well.

The following requirements for storage impoundment (i.e., reservoir) apply to reclaimed water of all three classifications:

- The following apply where reclaimed water is put in any impoundment used as a restricted recreational impoundment or landscape impoundment:
 - a. Runoff shall be prevented from entering the storage impoundment unless the impoundment is sized to accept the runoff without discharge, or an NPDES permit has been issued for the discharge;
 - b. There shall be no discharge of reclaimed water to any impoundment with less than two feet of freeboard; and
 - c. To retain its contents, impoundment shall have liners impervious to water;
- The time period of 20 days related to storage is subject to reduction, expansion, or elimination if the project proponent demonstrates to the satisfaction of the DOH that another time period is adequate or that less or no storage is needed. The record should be at least a 30 year period or statistically adjusted to a 30 year period;
- The design of system storage capacity shall be sufficient to assure the retention of the reclaimed water under adverse weather



conditions, harvesting conditions, maintenance of irrigation equipment, or other conditions which preclude reuse. The adverse wet weather conditions shall be based on a 50-year storm recurrence interval using weather data that is available from, or is representative of, the area encompassing the design project; and

- The control of public access is left to the discretion of the Owner. However, signs shall be posted that are consistent with the Public Education Plan of these guidelines.

All new buried transmission piping in the reclaimed water system, including service lines, valves, and other appurtenances shall both be colored purple, and embossed or be integrally stamped/marked "CAUTION: RECLAIMED WATER—DO NOT DRINK", or be installed with a purple identification tape, or a purple polyethylene wrap. Existing potable or nonpotable water lines that are being converted to reclaimed use shall first be accurately located and tested in coordination with DOH.

The maximum monthly application rate of reclaimed water used to calculate both the volume of the storage reservoir and/or an alternate disposal capacity is to be based on the following parameters:

- Evapotranspiration
- Precipitation
- Percolation

Nitrate and total phosphorus concentration in the percolate is also a factor in determining the maximum application rate. The nitrate concentration in reuse irrigation systems should not exceed 3.0 mg/l, and the total phosphorus concentration should not exceed 1.0 mg/l. The maximum monthly application rate — based on evapotranspiration, precipitation and percolation — should be checked against the nitrogen and phosphorus loading limitations.



A detailed presentation on calculation of the application rate and reservoir capacity is included in Section VIII of this study, where the alternatives are evaluated. However, calculations to determine the estimated nitrogen and phosphorus loadings will not be included in this study, since the type of detail required is better suited to Basis of Design Report, which is not within the scope of this study.

C. NPDES

In 1972, the U.S. Congress passed amendments to the Federal Water Pollution Control Act (referred to as the Clean Water Act) prohibiting the discharge of any pollutant to navigable waters from a point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. The NPDES program was traditionally focused primarily on reducing pollutants in discharges of industrial process wastewater and municipal sewage. However, in 1988 the "National Water Quality Inventory" concluded that pollution from diffuse sources, i.e., storm water runoff from agricultural and urban areas, are leading causes of water pollution.

The Clean Water Branch of DOH is responsible for the issuance of NPDES permits. The requirements for NPDES permits are stated in Hawaii Administrative Rules, Title 11, Chapter 55, "Water Pollution Control", which was adopted in October of 1992. There are two categories of NPDES permits – General Permits and Individual Permits. Under DOH's General Permit (GP) Program, six categories of storm water and non-storm discharges are covered.

At the present time, no GPs are required for the Waimea WWTP. One GP which may be required in the future if modifications are made to the lower effluent reservoir, is a GP which covers storm water discharges associated with construction activities. Currently, this GP applies to construction areas of five acres or more. However, there is a strong possibility that the requirements will



become more stringent in the near future and the area may be reduced from five acres to one acre.

Presently, Kekaha utilizes effluent from the Waimea WWTP, which has been mixed with storm water, for sugar cane cultivation. The effluent is conveyed from the lower reservoir to the cane fields via a series of irrigation ditches. Excess effluent and stormwater drains from the fields to the irrigation ditches. This agricultural drainage is then pumped and recycled to other fields. During dry conditions, this effluent/storm water mixture does not enter the ocean. However, during storm conditions, overflow may occur, during which the effluent may enter the ocean. Kekaha has an individual NPDES permit (No. HI0000086) which covers this type of discharge.

In the future, if Kekaha discontinues using the effluent for sugar cane irrigation, then a new NPDES permit would be required since effluent discharges to state waters would no longer be covered under Kekaha's permit. The owner of the system from which a discharge may occur (i.e., overflow from the storage reservoir, or runoff from irrigated fields), most likely, would be the party required to obtain the NPDES permit.

VII. EVALUATION CRITERIA

A. Treatment Efficiency

Pursuant to DOH's Chapter 62 and Water Reclamation Guidelines, the following minimum effluent quality must be achieved for the alternatives being considered (i.e., reuse and/or injection wells):

- Average BOD concentration of 30 mg/l
- Average TSS concentration of 30 mg/l
- Median Fecal coliform value of 4 per 100 ml

Presently, the Waimea WWTP meets these criteria. In fact, the effluent BOD and TSS concentrations are on the order of 3 and 5 mg/l, respectively. (See Table 5.) Also, as stated previously in Section VI, EPA and the State will not require nutrient removal prior to effluent disposal via injection wells.

B. Flow Rates/Volumes

Presently, flow rates at the Waimea WWTP are consistent throughout the year, with a monthly average range of 210,000-270,000 gpd. The median flow rate is 240,000 gpd. (See Table 5.)

Also, peak days recorded over the past three years indicate that a peak day factor of 2.0 is appropriate. This peak day factor is based on DOH's letter, which states that historical flow records may be used as a substitute for the Babbitt formula. (See Appendix E.) This conclusion is significant, in that calculation of the peak factor using the Babbitt formula — as required by DOH's Chapter 62 — would result in a factor of 4.0. Applying this conclusion to the DOH requirement that the injection well must accommodate the peak flow would result in a two-fold capacity difference.

Another flow-related matter is that expansion of the WWTP beyond its current 300,000 gpd capacity is dependent on development of the Kikiaola Master Plan.



The 1971 Austin, Smith & Associates, Inc. Preliminary Engineering Study estimated a first phase average flow of 272,000 gpd, and an ultimate flow of 442,000 gpd. The first phase projection was realized, as there are only 72 house lots in Waimea that are yet to hook up to the County system (62 lots are still vacant). Based on 400± gpd per lot, the additional flow from these lots would be 29,000 gpd, resulting in an ultimate flow of about 270,000 gpd.

C. Storage

The existing lower reservoir – which currently receives effluent from the WWTP – is intended to be the ultimate storage reservoir for the reclaimed water. This 8± million gallon reservoir has the capacity to accommodate DOH's "rule-of-thumb" 20-day storage capacity requirement for the current 300,000 gpd flow. It can probably be demonstrated that – because of the generally low-rainfall climatic condition of the study area – less than 20 days of storage would be sufficient, thereby accommodating the 600,000 gpd ultimate flow of this study.

At the present time, lining of the storage reservoir is not required. However, when DOH's reclamation guidelines are signed into law (mid-to-late 1995), all new and existing effluent storage reservoirs will need to be lined. There are two exceptions in which lining the reservoir would not be necessary, they are:

- (1) If the soil of the reservoir has a permeability less than 10^{-7} cm/s, then the soil would be considered impervious; and
- (2) Monitoring test results prove that groundwater quality in the surrounding area is not negatively affected.

The inlet and outlet piping would also need to be modified.

D. Irrigation Method

The three methods of irrigation considered were drip, spray and surface (other than spray). DOH's definitions for these three methods – in their water reclamation guidelines – are as follows:

- "Drip irrigation" means application of water from emitters, either on the surface or subsurface that are part of the piping system alongside the plants being irrigated and that discharges at a rate not to exceed 2 gallons per hour per emitter.

Subsurface drip irrigation means application of reclaimed water at least 4 inches below the finished grade, by discharging it from orifices in piping.

- "Spray irrigation" means application of reclaimed water to land to maintain vegetation or support growth of vegetation by spraying it from sprinklers, micro-sprinklers or orifices in piping.
- "Surface irrigation" means application of reclaimed water by means other than spraying such that contact between the edible portion of any food crop and reclaimed water is prevented.

Drip irrigation has the following advantages over the other two irrigation methods:

- Minimal health-related restrictions, in regards to hours of irrigation and setback distances from areas of potential public exposure to the applied water.
- Maximum application volume, due to a high uniformity coefficient – i.e., more even distribution across the irrigated area, thereby preventing ponding and runoff.
- Lower pressure requirement at the emitter (less than 20 psi vs. 60+ psi), which results in lower power cost and lower capital cost associated with lower-pressure transmission lines.





albeit minimal, due to limited precedence — in establishing a reuse program in Hawaii, the injection well alternative may take less time to implement.

H. Injection Well Constraints

DOH- and EPA-imposed constraints on injection wells primarily relate to the TDS concentration of the receiving aquifer being greater than 10,000 mg/l. Mink & Yuen, Inc. evaluated the alternative of injection wells and recommended that such wells be constructed along Kaumualii Highway, or between the highway and the coast. (See Appendix A for Mink & Yuen's report.)



The number, and discharge capacity, of injection wells is contingent upon implementation of a reuse system. The following scenarios are possible:

- No reclamation system. At least two injection wells, each with a capacity of 1.2 mgd.
- Reclamation system without a backup reservoir. At least one injection well with a capacity of 1.2 mgd.
- Reclamation system with a backup reservoir. No injection wells necessary.

Effluent quality criteria for the injection well alternative relates to the BOD, TSS and chlorine residual concentrations. The current performance of the WWTP is such that the concentrations of these three parameters are well within the limitations established by DOH (e.g., less than 10 mg/l BOD/TSS vs. DOH's maximum of 30 mg/l). As mentioned previously in Section VI of this report, EPA will not require nutrient removal if the conditions set forth in their letter are met. (See Appendix D.)

The estimated construction cost for each injection well is \$350,000. (See Table 8 for itemization.) The estimated cost for the effluent transmission line from the WWTP to the wells, including appurtenances, is \$60,000 (800 L.F. @ \$60/L.F. + \$5,000 misc. + 10% contingency).



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loadings would be calculated for a Basis of Design Report, which is not in the scope of this study.

Since all proposed reclamation areas are below the UIC Line, percolation of the effluent into the soil would be allowed. However, for comparison purposes, the application rate and the storage volume were calculated with percolation and without percolation, hence, the two sub-tables within each table.



Col. (10): MMAV = Maximum Monthly Application Volume for area makai of the highway.

$$\text{MMAV} = \text{MMAR} \times 100 \text{ acres} \times 0.02716 \text{ MG/acre-in}$$

$$\text{MMAV}_{\text{Feb}} = 172.34 \text{ in} \times 100 \text{ ac} \times 0.02716 \text{ MG/acre-in} \\ = \underline{468 \text{ MG}}$$

Col. (11): Total Use = Total MMAV for areas mauka and makai of the highway.

$$\text{Total Use}_{\text{Feb}} = 4.77 \text{ MG} + 468.08 \text{ MG} = \underline{472.85 \text{ MG}}$$

Col. (12): Flow = Design flow from the Waimea WWTP (current).

$$\text{Flow} = 300,000 \text{ gpd} \times 28 \text{ days} / 1,000,000 = \underline{8.4 \text{ MG}}$$

Col. (13): Surplus/Deficit = Surplus or deficit of the effluent. A negative value represents a deficit.

$$\text{Surplus/Deficit} = \text{Flow} - \text{Total Use}$$

$$\text{Surplus/Deficit}_{\text{Feb}} = 8.40 \text{ MG} - 472.85 \text{ MG} \\ = \underline{-464.45 \text{ MG}}$$

Col. (14): Cumulative surplus/deficit is the cumulative surplus or deficit over the length of the year.

$$\text{Cum. sur/def}_{\text{Feb}} = -502.16 \text{ MG} + -464.45 \text{ MG} \\ = \underline{-966.61 \text{ MG}}$$

Col. (15): Storage Volume required



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TABLE 18. ESTIMATED CONSTRUCTION COST FOR SCENARIO 1
IRRIGATION SYSTEM WITH SUGAR CANE MAUKA OF HIGHWAY
AND PASTURES MAKAI OF HIGHWAY

DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	TOTAL
HDPE Transmission Line mauka of highway	6,200	LF	\$15.00	\$93,000
HDPE Transmission Line makai of highway	5,800	LF	\$15.00	\$87,000
Central Pumping and Filtration Station and Control Center		Lump Sum		\$150,000
Irrigation Control System		Lump Sum		\$20,000
Subsurface Drip Irrigation for Sugar Cane mauka of highway	140	Acres	\$1,700.00	\$238,000
Subsurface Drip Irrigation for Pasture makai of highway	100	Acres	\$3,000.00	\$300,000
SUBTOTAL				\$888,000
10% CONTINGENCY				88,800
TOTAL				\$976,800
SAY				\$980,000



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TABLE 20. ESTIMATED CONSTRUCTION COST FOR SCENARIO 3
IRRIGATION SYSTEM WITH PASTURES MAUKA AND MAKAI OF HIGHWAY

DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	TOTAL
HDPE Transmission Line mauka of highway	6,200	LF	\$15.00	\$93,000
HDPE Transmission Line makai of highway	5,800	LF	\$15.00	\$87,000
Central Pumping and Filtration Station and Control Center		Lump Sum		\$150,000
Irrigation Control System		Lump Sum		\$20,000
Subsurface Drip Irrigation for Pasture mauka of highway	140	Acres	\$3,000.00	\$420,000
Subsurface Drip Irrigation for Pasture makai of highway	100	Acres	\$3,000.00	\$300,000
SUBTOTAL				\$1,070,000
10% CONTINGENCY				107,000
TOTAL				\$1,177,000
SAY				\$1,200,000



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The areas irrigated with both of these option is above the UIC Line, which would require stricter DOH conditions, including groundwater monitoring requirements. In further discussions with Kekaha, they indicated their reluctance to accept the effluent due to these stricter requirements. Therefore, a cost analysis of these two options was not pursued.



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EXHIBITS



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APPENDICES



AUSTIN, TEUTSUMI & ASSOCIATES, INC.
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APPENDIX A

"WASTE WATER EFFLUENT DISPOSAL
BY INJECTION WELLS",
BY MINK & YUEN, INC.
DATED AUGUST 1993

